For simplicity in the specification of an AOU standard, it is common to describe the area by the radius of a circle of equivalent area called the "radius of circular error probability" (Rcep), which is equal to the geometric mean of the semi-major and semi-minor axes for an ellipsoidal AOU. In the normal, two-dimensional situation, a 1-s.d. AOU will have a 39.35% probability of containing the true mean position, and a 2-s.d. AOU will have a 86.47% probability of containing the true position. In the JEM considerations of the facilities appropriate for wireless E-911 services, some participants suggested or agreed with the feeling that the uncertainty values representing a 90% probability of containment or confidence level (i.e., the 2.15-s.d. values) should be the basis for a performance standard. In any specification of a localization accuracy performance standard, KSI suggests that the Commission specify the probability of containment at which the standard is to apply. Thus, for the second stage of the implementation of E-911 for CMRS, we recommend that the Commission require the provision of a two-dimensional location (i.e., latitude and longitude) with an accuracy standard that is a radius of circular error probability not greater than 150 meters at the 90% probability of containment. Inclusion of a second stage accuracy requirement as suggested will ensure that the locations provided to the PSAP by the CMRS operators are meaningful and will help avoid the misdirection of emergency resources.

With similar consideration of the localization accuracy standards discussed for the second stage of implementation, KSI further recommends that the Commission adopt for the third stage of E-911 implementation an accuracy standard that is a radius of circular error probability not greater than 100 meters at the 90% probability of containment. KSI suggests a requirement of 100 meters, rather than the 125 meters specified in the NPRM (at para. 51), because the measured performance of the prototype DFLS configuration routinely meets or surpasses the 100 meter level today.

VII. CONCLUSION

For the reasons set forth herein and as further detailed in the Appendices to these Comments, KSI urges the FCC to expeditiously adopt the NPRM in this proceeding with the modifications suggested herein.

Respectfully submitted,
KSI Inc.

By: ______________________
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APPENDIX A

KSI CORPORATE QUALIFICATIONS

KSI Inc. is a highly respected, capable, high technology research and development corporation. Located in Annandale, Virginia, KSI's employees have provided research and development, and analytical systems and software engineering support to the Government and to commercial clients since the early 1970s. KSI's personnel have extensive experience in the research, the algorithm development, and the use of innovative signal analysis procedures. In a variety of systems our signal processing techniques have been implemented on advanced digital processors to perform on-line, real-time surveillance tasks. We have also undertaken many algorithm optimization tasks to improve performance and maximize data throughput. Our scientists are recognized as having designed, developed, and implemented innovative, practical, and efficient signal analysis algorithms and target-tracking filters, primarily for passive surveillance applications. Our expertise encompasses time-, frequency-, and spatial-domain analyses; digital filter design; demodulators; coherence, correlation, and ambiguity function techniques; multichannel analyses; waveform design; performance prediction; statistical modeling; propagation analysis; detection theory; and noise evaluation.

KSI's staff possesses extensive experience in a variety of areas pertaining to the broad subject of hydroacoustic signal processing, and specifically, to anti-submarine warfare. This experience was gained through work either as a prime contractor to the U.S. Navy or as a subcontractor to the defense industry. In some cases, our efforts involved the development of optimized software configurations that implemented innovative narrowband and broadband algorithms used in threat target detection, localization, tracking, and characterization. In other applications, KSI's personnel have been responsible for the development, implementation, test and evaluation, and installation of large, stand-alone, digital processing systems which are important to our nation's intelligence analysis or real-time undersea surveillance capabilities. This systems work, it should be noted, has involved extensive system and software documentation (including fully compliant MIL-STD software development and documentation), operator training, and on-site operation and maintenance so as to insure that system availability and operability are maximized at all times.

Our scientists/engineers have made significant state-of-the-art advances in the passive signal processing of hydroacoustic signals. For example, the advances in the area of inter-array processing (IAP) required a substantial research effort, involving the development of stand-alone, real-time computer systems which performed all of the necessary signal processing, target tracking, interactive display, and operational control functions. These systems, which today are fleet-deployed, exploit a high degree of automation and make extensive use of advanced graphics for operator interaction. The present generation of advanced IAP systems has been delivered under the direction and with the assistance of personnel now at KSI, and was developed in conformance with MIL-STD 1679. The system configuration incorporated innovative signal analysis and target tracking procedures designed by KSI personnel and is characterized by significantly increased throughput, simplified man-machine interfaces (MMI), and the use of the latest off-the-shelf hardware.

Short descriptions of senior staff follow:

Mr. Robert E. Beal has nineteen years experience in systems acquisition and technical program management: two years as a senior member of the KSI technical staff; five years technical director of MCCI, a small signal processing research and development firm; and twelve years as a Naval Officer where he was a designated Weapon System Acquisition Manager and Aeronautical Engineering Duty Officer. In addition to holding BS, MS, and AeE degrees, Mr. Beal is a graduate of the Defense Systems Management College. Mr. Beal has been the A-3 aircraft Weapon System Manager and deputy program manager for the acoustic search sensor research and development programs at the Naval Air Systems Command, Special Assistant for Air Anti-submarine Warfare, Undersea Surveillance, and Acoustic Signal Processing to the Assistant Secretary of the Navy (R,E & S); and Plant Representative Officer at the Japan Aircraft Manufacturing Company. Mr. Beal has extensive experience performing system engineering and integration work on DoD undersea surveillance programs. His experience in this area covers the broad spectrum of systems engineering management from specifying the initial requirements through system design, development, and test. His technical accomplishments include the development of a software development tool for the Navy's AN/UYS-2 signal processor, signal processing software and algorithms for a helicopter Advanced Low Frequency Sonar, modeling and beamforming support to the physical acoustics branch of the Naval Research Laboratory, and design of a multi-purpose beamformer for the Naval Weapons Surface Center. He has formulated and implemented program plans, acquisition strategies, budgets, and schedules, and executed programs for the development of 10 acoustic search sensors, 15 aircraft retrofit programs, and numerous research and development programs. In addition to his program management and technical qualifications, Mr. Beal has a strong background in logistics.

<u>Ms. Carol A. Halpeny</u> has been engaged in applied research and development, primarily in the area of underwater acoustics and sonar systems, for over 20 years. She has been actively involved in the development of advanced detection, classification, and localization and tracking algorithms for a variety of tactical and surveillance applications. Her responsibilities, both managerial

and technical in nature, have included assuring technical quality, scheduling, cost estimation and control, customer interaction, training, informal meetings and presentations, and formal program reviews. Ms. Halpeny has remained a Registered Professional Engineer (Civil) and Land Surveyor for over 25 years. She is currently a member of the IVHS America committees on Advanced Rural Transportation Systems (ARTS) (and planning subcommittee), Advanced Traveler Information Systems (ATIS) (and subcommittee on Personal Portable ATIS), and the Communications Spectrum Task Force. She is also a member of IEEE and ASCE.

Mr. Charles J. Hinkle, a coinventer of the pending EDFS patent, has served in management and executive level positions in all aspects of finance, direct sales, and marketing at various organizations over the past twenty-two years. He is adept at all phases of business operations from start-up through daily operations, and has two decades of experience in the legal nuances of contract relations and in project management for both commercial and government-oriented services and products. He is a co-founder of KSI Inc. and has served as a member of its Board of Directors, Treasurer, and Director of Marketing since its inception in 1986. He has worked with Drs. Stevenson and Maloney, and Ms. Halpeny since 1976. He has directed and contributed to all DFLS management and marketing efforts to date and is the focus of all of KSI's IVHS-related activities. He is a long-standing member of IVHS America committees and subcommittees, including those on Advanced Traffic Management Systems (ATMS) and Advanced

Traveler Information Systems (ATIS). He has been a speaker at transportation conferences, such as those of the Transportation Research Board (TRB), and has been instrumental in building the interest of the wireless community in transportation system opportunities.

Dr. John E. Maloney, the co-inventor and patent author of the DFLS patent and the pending EDFS patent, has been designing, developing, and delivering detection, localization, and tracking systems since 1971. He has conducted fundamental research in the development of advanced signal processing and source tracking algorithms that has led to the deployment of sonar and RF systems with previously unachievable robustness and accuracy. His experience has also led naturally to the innovative, yet simple, design concepts that are embodied in DFLS. His design efforts have been characterized by an appreciation of the needs for simple and robust implementations of complex technologies to meet the realities of development and operational requirements. He is a member of the IVHS America committees for Architecture and for Advanced Traffic Management Systems (ATMS) (and its Architecture subcommittee). He is also a member of IEEE and ACM.

Dr. James O. Stevenson, a coinventer of the pending EDFS patent, has twenty years of experience developing, refining, and implementing advanced signal tracking systems. He has configured these inherently complex systems so that they can be operated by junior personnel in real-world, operational environments. He has directed the design and implementation of key components of the Inter-Array Processor, the Air Common Acoustic Processor, the Fixed Distributed System Testbed Evaluation facility, and the Automated Surveillance Information Processing System Evaluation facilities. He directs the system and software engineering efforts of his supporting team members, applying state-of-the-art software design concepts and practices. He is a student of software design and implementation, and has remained abreast of the evolving software development methodologies as the languages, operating systems, design techniques, and implementation techniques have grown and matured over the past two decades.

APPENDIX B

DFLS SYSTEM DESCRIPTION

KSI's DFLS is network infrastructure-based. Since our system determines the location of the transmitter merely from the direction angles of arrival of the RF signals, it is not limited to locating voice communications, but rather can derive locations from data as well, even the short data transmissions of the system control messages. In the descriptions below, screen displays of locations derived from actual cellular transmissions from KSI's test phones are included to aid in the understanding of the system capabilities. In those displays, the position data (ALI) are real, while the ten digit ANI and the number called have been modified for privacy.

The DFLS technology can provide the automatic location and number identification (ALI and ANI) needed to implement E 9-1-1. No modifications are necessary to the cellular or PCS phone or any other transmitter in a wireless communication system. DFLS detects radio frequency (RF) emissions using phased-array antennas and receivers as sensors that operate passively in the wireless phone frequency bands. DFLS processes the RF array data to obtain the location (Direction Finding) of the calling vehicle, and then evaluates and displays the identification and position data for monitoring and response. The necessary processing can be accomplished with the call-initiating control signal, which lasts only one tenth of a second, and the location for a 9-1-1 call can be available before the voice communications are established. Thus, the location can be used for call routing and for immediate support to the PSAP operator taking the call. Our ability to automatically locate any caller requesting or reporting a need for assistance can be integrated with such wireless communications capabilities as cellular or PCS. The resultant Emergency Notification and Personal Security (ENPS) approach enables rapid determination of ALI and ANI, and thus allows the public safety operator to focus on determining the nature of the problem and provides positive confirmation to the caller that a response is underway.

As represented in Figures 1 and 2, DFLS exploits a wireless telephone system configuration with the installation of special receiving antennas at dispersed sites called Sensor Stations (SSs). These antennas, which might be installed at the wireless system antenna sites, receive the transmitted (control or voice) signals. DFLS then processes these signals to determine their angle of arrival. For wireless phone localization, it is not necessary for the phone to be transmitting voice signals. It is only necessary that the phone be turned on for control signals. However, during voice transmissions, extended detection opportunities exist for localization and tracking. Upon detection at the SS antenna sites, the calculated directional information is then relayed via data link to a central control location, called a

Control Station (CS). The CS serves as a command center, where the directional information is automatically processed to obtain locations which are displayed in tabular form and on computer-based maps.

Our demonstration configuration of DFLS consists of a two-site system. One site supports the dual role of a SS and the CS. Figures 3 and 4 contain actual output from a CS computer located in Annandale, VA. These figures cover the local geographic area, with the control and

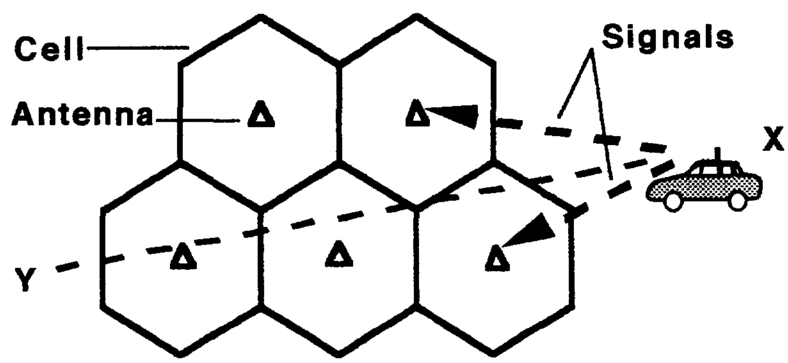

Figure 1 Conceptual Wireless Area Coverage

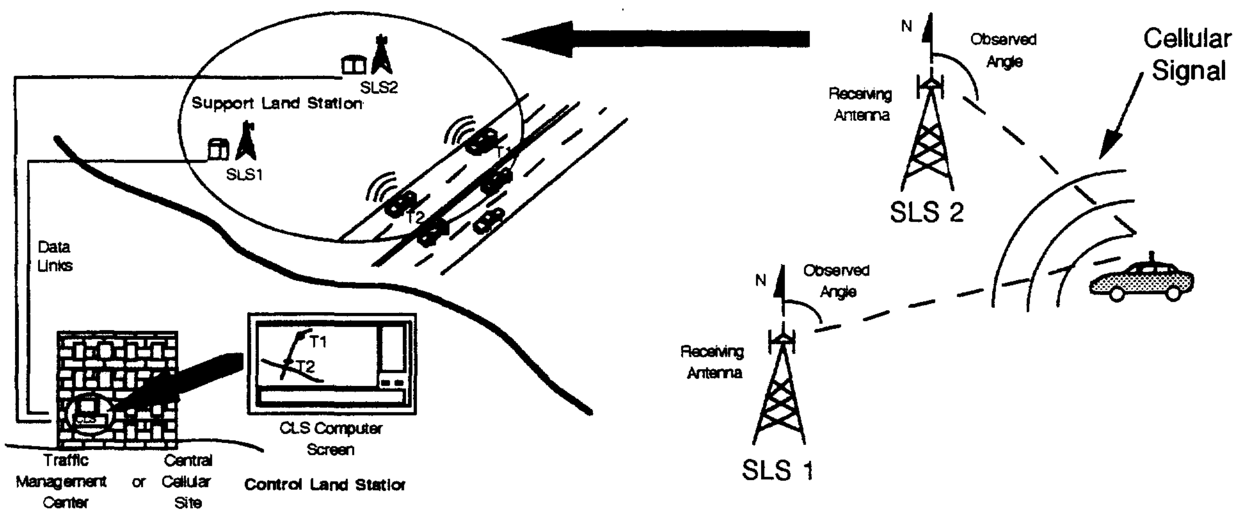

Figure 2 DFLS System

sensor sites marked as CLS and SLS respectively. As shown, actual direction measurements from these two sites were used to calculate the position of mobile wireless phones, which are each represented by circles approximately 37 meters in radius. Each circle has an associated index number which is cross-referenced to a particular phone and tabulated in the lower scroll area of the screen. Alternative operating modes enable the monitoring of:

- phones calling specific numbers, such as 9-1-1;
- a set of specifically identified phones; or
- all phones in operation in a specific area.

Our results graphically demonstrate that persons needing assistance or third parties reporting needs for assistance can easily be located with DFLS.

Figure 4 presents the results of tracking a phone in space and time. As the direction angle data from multiple SSs are obtained, they in turn are used to produce location and speed information in near real-time. Tracking of vehicles in motion will be important to service calls-for-assistance from callers that are having a problem while moving and from third-party assistance callers that report a problem relative to their own position and motion. DFLS can facilitate

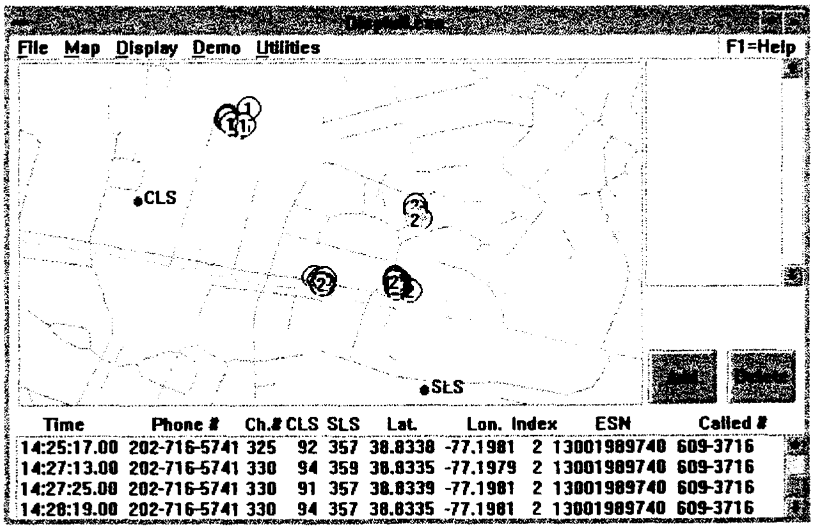

Figure 3 DFLS Output - Stationary Phone

locating calling vehicles involved in incidents, and can also locate clusters of calls regarding the same incident. Through operator interaction and awareness of the caller's location, triage methods and recorded messages could be applied to an overload of calls from the vicinity of a particular incident to minimize the number of critical callers from other incidents that are diverted to a queue. Throttling techniques such as these could be employed as appropriate to ensure that calls for help concerning distinct incidents can be serviced expeditiously.

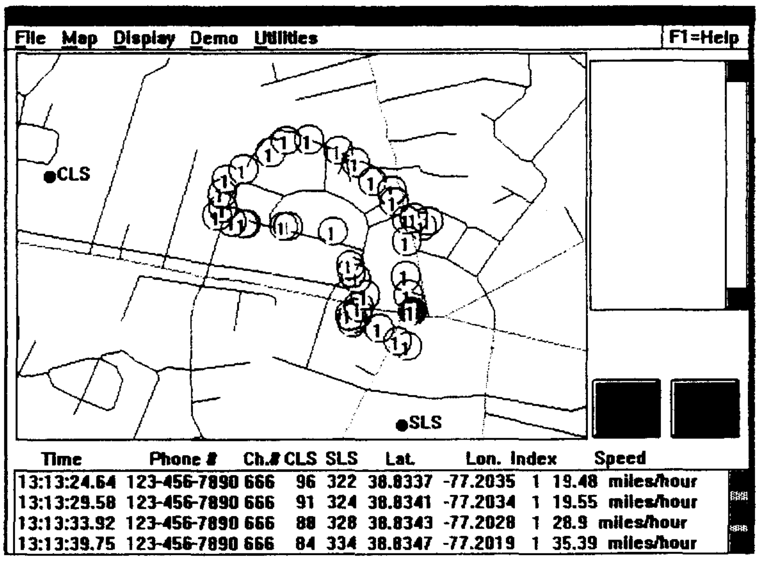

Figure 4 Source Tracking

In enabling wireless E 9-1-1, DFLS can also, as mentioned previously, facilitate the achievement of key goals for the Intelligent Vehicle Highway System (IVHS) program. IVHS has as a goal a communications and traffic management system in 245 cities nationwide within the next 15 years. The existing urban and rural areas with wireless coverage exceed that number today, and PCS will expand coverage far beyond current IVHS goals. It is not necessary to wait 15 years to achieve the IVHS goal.

Communications companies could provide both communications and location services to DOTs. Rural areas are of particular concern to transportation and public safety officials because statistics show that 57% of traffic fatalities occur in rural areas. With the implementation of a DFLS-based system, an emergency notification and personal security service, for cellular-, PCS-, and SMR-like systems, could be implemented in two to five years in both rural and urban areas.

DFLS's ability to locate standard wireless phones can provide a natural link between the provision of E 9-1-1 and traffic monitoring. Based on years of experience and sound engineering principles, DFLS technology represents a simple, inexpensive, low risk solution for those applications where wireless communication signal location and identification are desired for E 9-1-1, traffic monitoring, and other service applications. Most alternative technologies require, at the point of mobile communication, both a location or navigation system and communication equipment, which increases system complexity and cost, and deters user acceptance. The ability of DFLS to locate standard phones used in reporting incidents and related traffic conditions, and to monitor and extrapolate traffic conditions based on the actions of wireless-equipped vehicles, makes DFLS a prime technology for multiple Communications and DOT applications.

Our approach for E 9-1-1 can augment existing systems (such as cellular) for ease in phase-in and is also compatible with the evolution to PCS and with digital approaches such as TDMA and CDMA. While our prototype configuration exploits crossfixing or triangulation with data extracted at multiple receiving sites, we also realize that both the rural communications environment and CDMA implementations with aggressive power management may at times make it preferable to implement a system exploiting only single-site reception. For such applications, we have devised, and filed for patent protection on, a less equipment-intensive yet eloquently simple additional solution. This alternative system configuration is called the Enhanced Direction Finding System (EDFS). In contrast to other approaches, EDFS can exploit a single-site line-of-bearing (LOB) which is correlated with other collateral information in the determination of the location of the mobile communications unit.

We have constructed a demonstration configuration of EDFS which is a single-site system where one site supports the dual role of a SS and the CS. Figure 6 presents actual output from a CS computer. The map of the local geographic area is shown with the CS/SS site marked as CLS. The shown actual direction measurements from the site were used to calculate the position of a mobile wireless phone known to be on a particular road (Route 50). The calculated position is indicated by an ellipse representing the probable location of the vehicle. Figure 7 shows an expanded view of the localization. Future communication embodiments, cost, or rural applications, may require implementation of simple location solutions in a timely manner. EDFS is such a simple yet robust solution

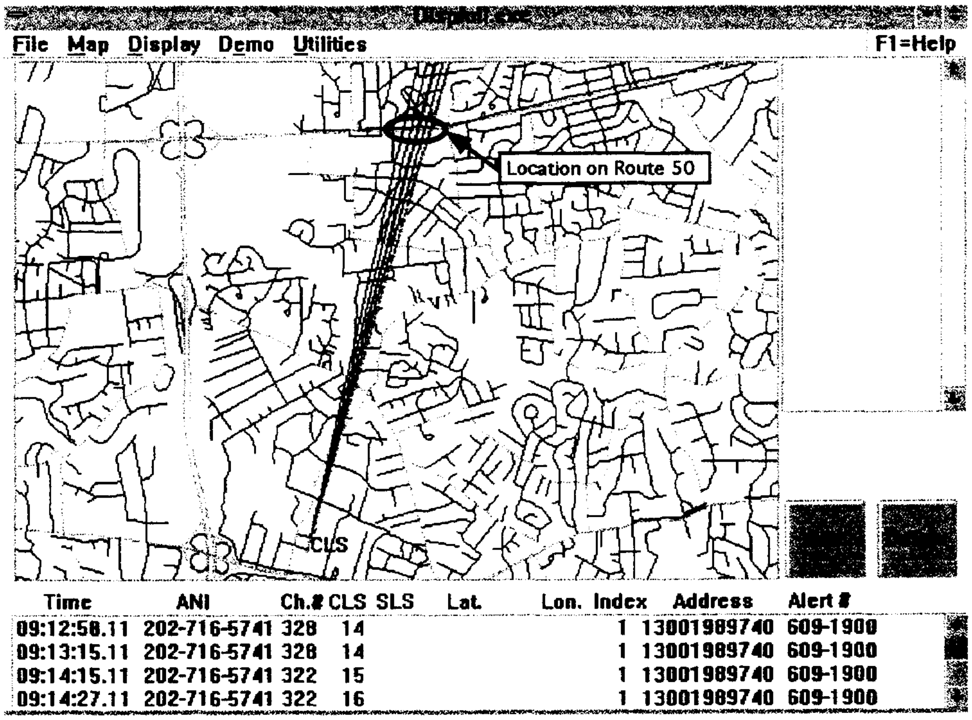

Figure 5 Localization with Bearing/Map Matching

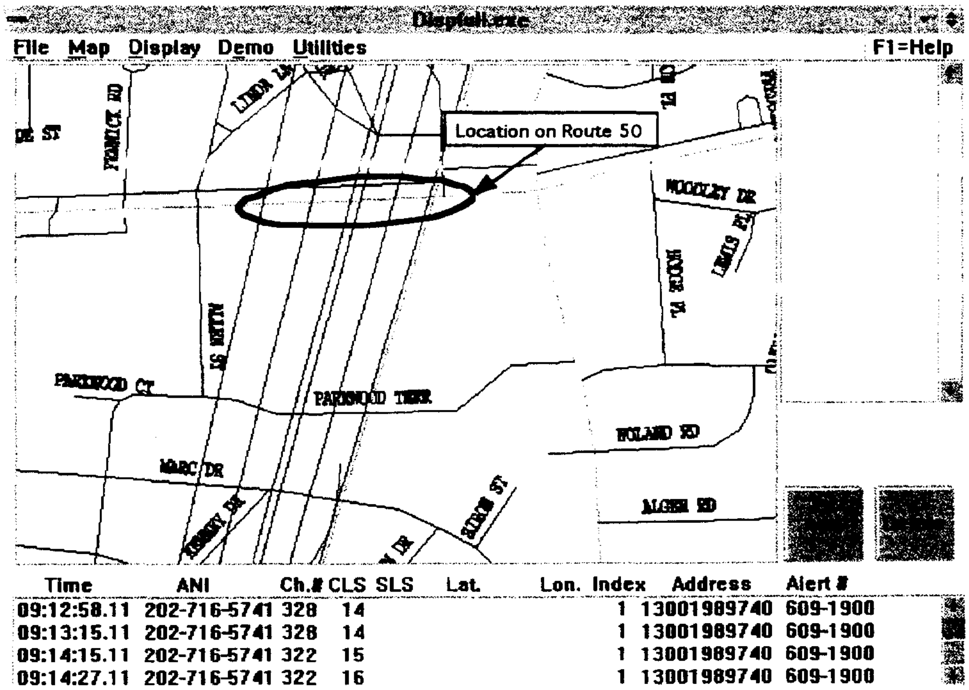

Figure 6 Zoomed View of Localization

APPENDIX C

ALTERNATIVE LOCATION TECHNOLOGIES

There are alternative technologies for providing position/location. In contrast to DFLS, most alternative technologies require a mobile station and a location or navigation system and communication equipment, which increases system complexity and, hence, cost. The alternative technologies are: (1) Loran-C or other land-based reference transmission systems, (2) terrain navigation, and (3) time of arrival systems, including those applying the Global Positioning System (GPS). Additionally, there is a competing, but more complex and limited, implementation of the cellular localization technology which applies time difference of arrival techniques. Each of these technologies is described below.

Every one of the alternative approaches in the following descriptions requires the installation of autonomous equipment in each vehicle, designed specifically for the localization function. The competing cellular implementation method is also addressed in the discussions of land systems.

Loran-C is a low frequency (90-110 kHz) transmitter network that covers about 63% of the land area of the U.S., with the greatest coverage in the eastern U.S. It is also available in parts of several other countries. Systems based on other reference transmitters can exploit broadcast radio or cellular base-station signals. For position determination, a special receiver in a vehicle receives the reference signals and determines the vehicle's latitude and longitude based on the characteristics of those signals. For applications that require the location information at a site external to the vehicle, these data must then be transmitted from the vehicle to a central site where further calculations can be made to produce positions that are displayed on a local map. The data can be transmitted through any appropriate communications system, including a cellular one. The accuracy available with Loran is about 500 feet. The actual polling of vehicles for their position takes place from the user base station where appropriate transmitter and receiver equipment is located.

Terrain navigation systems use what is called "dead reckoning" (DR) or "map matching" (MM). In a DR system, calculations are made concerning distance and direction traveled relative to where the vehicle started or was last calibrated. This system uses sensors on the vehicle to measure parameters such as tire rotation for distance and compass orientation for direction. In one system, an on-board computer-based unit performs the calculations and displays to the driver the vehicle's location on a local map. This system is presently being marketed as a driver aid. It could, however, be upgraded to transmit coordinate data back to a user base station, much as other vehicle-based systems do when an add-on communication device is installed in the vehicles. The system produces location coordinates and typically includes a map display. To maintain accuracy, these systems require periodic recalibration, either manual or automated, through integration with another system such as map matching and/or satellite positioning.

A MM system uses DR techniques, but also includes the processing of the sensor information in concert with a stored data base representing the road and street structure in the area in which the vehicle is operating. Thus the calculated locations can be continuously adjusted to conform to the nearest "known" street. When significant changes in direction of motion are detected, they are matched to the most likely feature represented in the map data and this map data location is used to adjust the assumed vehicle location. This approach assumes that the processing and database facilities are installed in any vehicle using these techniques, and also requires an add-on communication device to be installed if the location information is to be used at a site external to the vehicle.

Land systems utilizing the "TDOA" method typically employ a radio frequency (RF) transmitter in the vehicle and receivers at multiple antenna sites. The RF transmitter broadcasts enough power to allow line-of-sight reception, but not cause site saturation and anomalous propagation, and the signals are coded with enough bandwidth to provide very high timing accuracies (inversely proportional to the bandwidth) to attain useful localization accuracies. For utility in the timing measurements, the clocking mechanisms at all sites, between which the signal times are to be compared, must be maintained in synchronization to better than the timing accuracies desired for the measurements, i.e., less than one microsecond. This degree of synchronization is technically challenging, and is a burden that is not required for DFLS's time tagging of directional measurements to an accuracy of approximately one second. In the "TOA" approach, the transmitter's distance from each antenna (receiver) can be calculated by evaluating the signal propagation time of arrival estimates at each receiver. Time of arrival of the signal is compared to the "known" time of transmission from the vehicle. Alternatively, the differences (TDOAs) in times of signal arrival at the different sites can infer range differences from which the transmitter's location can be determined. When three or more estimates from distinct sites are available, the location can be calculated. This technology requires the establishment of an infrastructure of separate processor-controlled transmission or reception antenna sites and/or the installation of a processor-controlled transmitter or transponder in each vehicle. As another alternative, an attempt may be made to obtain TDOA measurements from standard cellular telephone signals. However, the limited bandwidth of the signals, the timing synchronization requirements, and the complexity and "back-haul" communications burdens of signal "pattern" comparison all render this approach economically infeasible and significantly less accurate relative to the direction finding (DF) approach. Simple, standard, Cramer-Rao analysis of the statistics for each approach demonstrates that our DF approach is typically ten (10) times more accurate than the TDOA approach with standard cellular (voice and/or control) signals. Our personnel explored the TDOA methods in 1984-85 and abandoned them as far more costly and complex, and less accurate, than DFLS.

Satellite systems rely on signals transmitted to or from three or more satellites (or two satellites and a fixed ground station) to a receiver. These signals are of known form and are appropriately coded with enough bandwidth so that the receiver location can be determined by the receipt of three or more of these signals synchronously. In one (terminated) system approach for commercial use, the actual positioning calculations were to be performed at a central site on the ground with the results then transmitted by satellite or land-based communication links to the users' locations. The most noteworthy of the satellite-based systems is the DoD's GPS, recently demonstrated to be extremely successful in the open desert environment. GPS is designed to provide a coarse accuracy for public use, comparable to or less precise than that anticipated for DFLS, and a precise accuracy for U.S. and allied military use. The public often can obtain the precise accuracy, but the military agencies reserve the right to alter the signals so that it is lost to all but authorized users at their discretion. Furthermore, the satellite signals can often be blocked by buildings or foliage in urban environments and thus, for applications in cities, currently developing systems often integrate GPS devices with DR and MM technologies in a single, complex, processor-based (costly) approach.

A GPS receiver only functions when its antenna for satellite signal reception is unobstructed by overhead foliage or nearby building structures. For a GPS receiver to function inside a vehicle or building, it must be connected to an unobstructed, external antenna. We have found that not only must the antenna be in a clear, open area for correct operation, but also the unit works best when the antenna is aligned vertically and is unobstructed by people. In our studies, we use the latest technology in hand-held GPS receivers. These observations are supported not only by our experience with our receiver, but also by the manufacturer's experience as well. GPS use is too restricted to satisfy the need for a robust, wireless E 9-1-1 capability.

Even when GPS is used in an unobstructed environment, GPS positioning information is not always readily available. Once the receiver has been initialized, it requires about 55 seconds to obtain its first location fix. Under follow-up conditions, an initial fix can be obtained within 30 seconds. However, to be useful for call routing to the appropriate PSAP, location